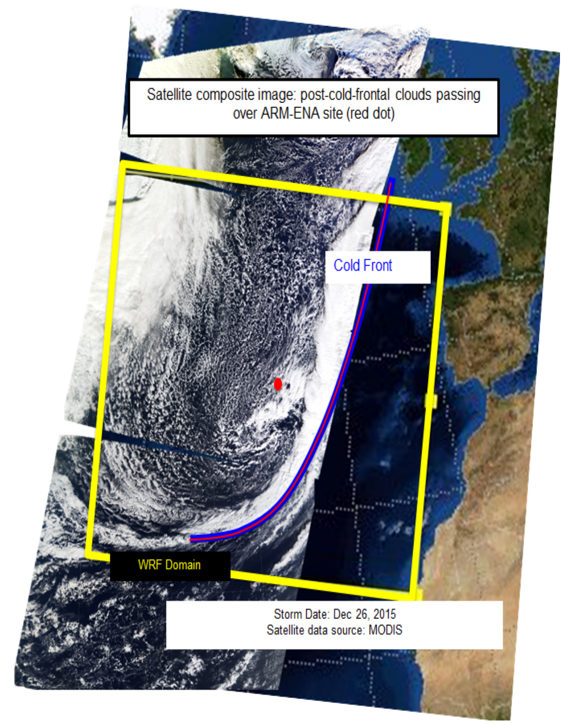
Understanding how large-scale circulation affects low-level clouds: How best to use ACE-ENA data?

Catherine Naud, Jimmy Booth, and Fayçal Lamraoui



See also:
F. Lamraoui talk, Tuesday 11.30 am
Poster, Tuesday, #69, A2

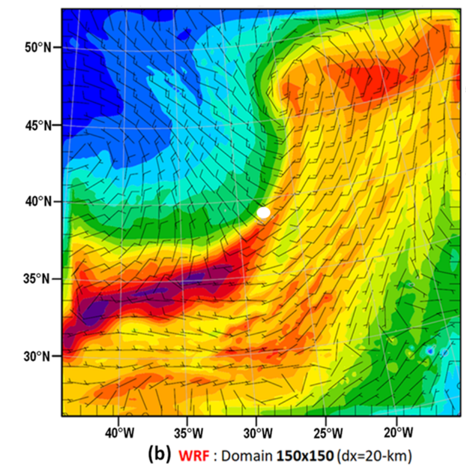
Context for our research interests: cold sector of extratropical cyclones

- What are **post-cold frontal (PCF)** conditions?
  Cold sector of a cyclone, region in the wake of a cold front with strong subsidence and mostly low-level clouds
- Why are we interested?
  GCMs suffer from underestimate in low-level cloud amount, and it is most acute in **post-cold frontal regions**. This issue is problematic for southern hemisphere energetics.
- What do we do?
  More observations needed of cloud properties themselves (not specifically examined yet), and important to have this info for constraining/evaluating shallow convection and PBL parameterizations
- How do we do it? Use ENA site observations to get a better understanding of clouds in PCFs and contrast with non-PCF low-level clouds

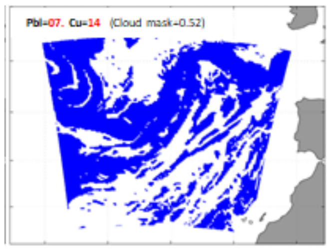
Interactions with ACE-ENA

- What it brings that is very useful to us: cloud and aerosol detailed observations, at and near the site, esp. microphysics.
- What we can contribute:
  - WRF simulations of case studies (c.f Lamraoui et al MWR2018 under review)
  - synoptic classification: based on reanalysis/surface observations
- Notable date for extensive study: Feb. 15 cold front passage

WRF simulation: cold front (PW) on 2015-12-25



Distribution of clouds below 5 km



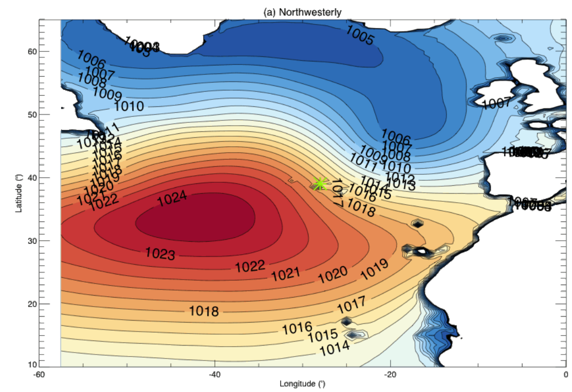
Clouds in PCFs at ENA

Identified 77 cases of PCF condition (i.e. a cold front has passed over the site, northwesterly winds prevail and subsidence for at least 2 hours after that) from CAP-MBL and post 2013:

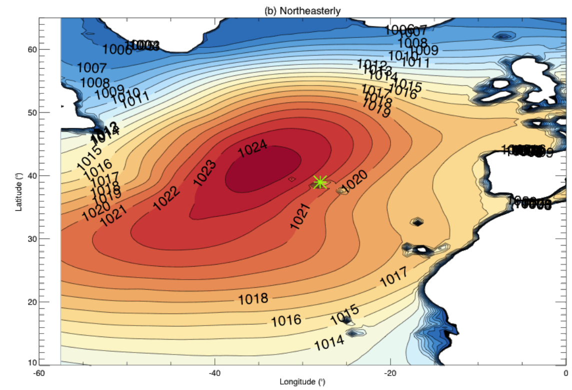
- 2/3rd of the time during PCF clouds are detected by micropulse lidar
- 85% of these clouds have a cloud base < 3 km and 75% CBH and CTH < 3 km
- Precipitation is only detected ~ 6% of the time

To compare PCF clouds to other low-level clouds, we identify periods with 1) subsidence and 2) northeasterly winds, that are not identified as PCFs.
➔ non-PCF periods

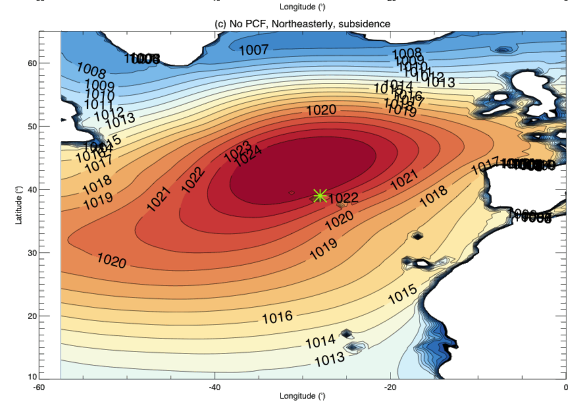
Surface Pressure:
PCF =>



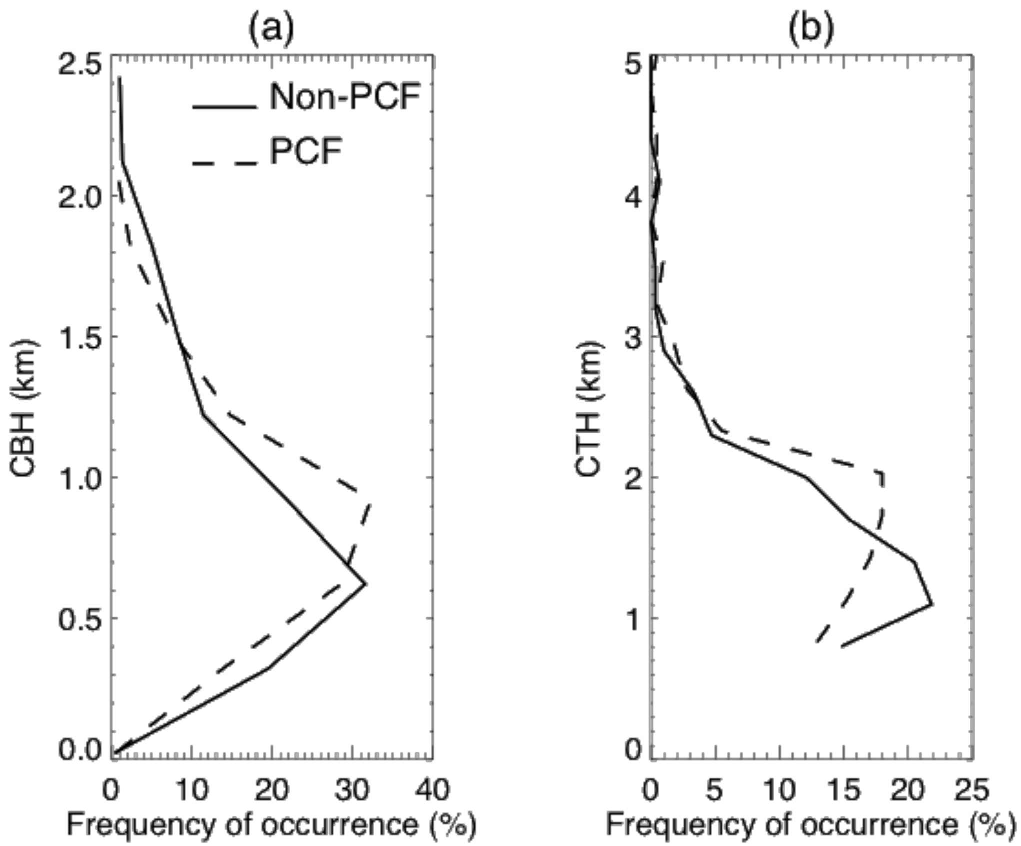
PCF "end" =>



Non-PCF =>



Cloud base and top height distributions: PCF vs. non-PCF

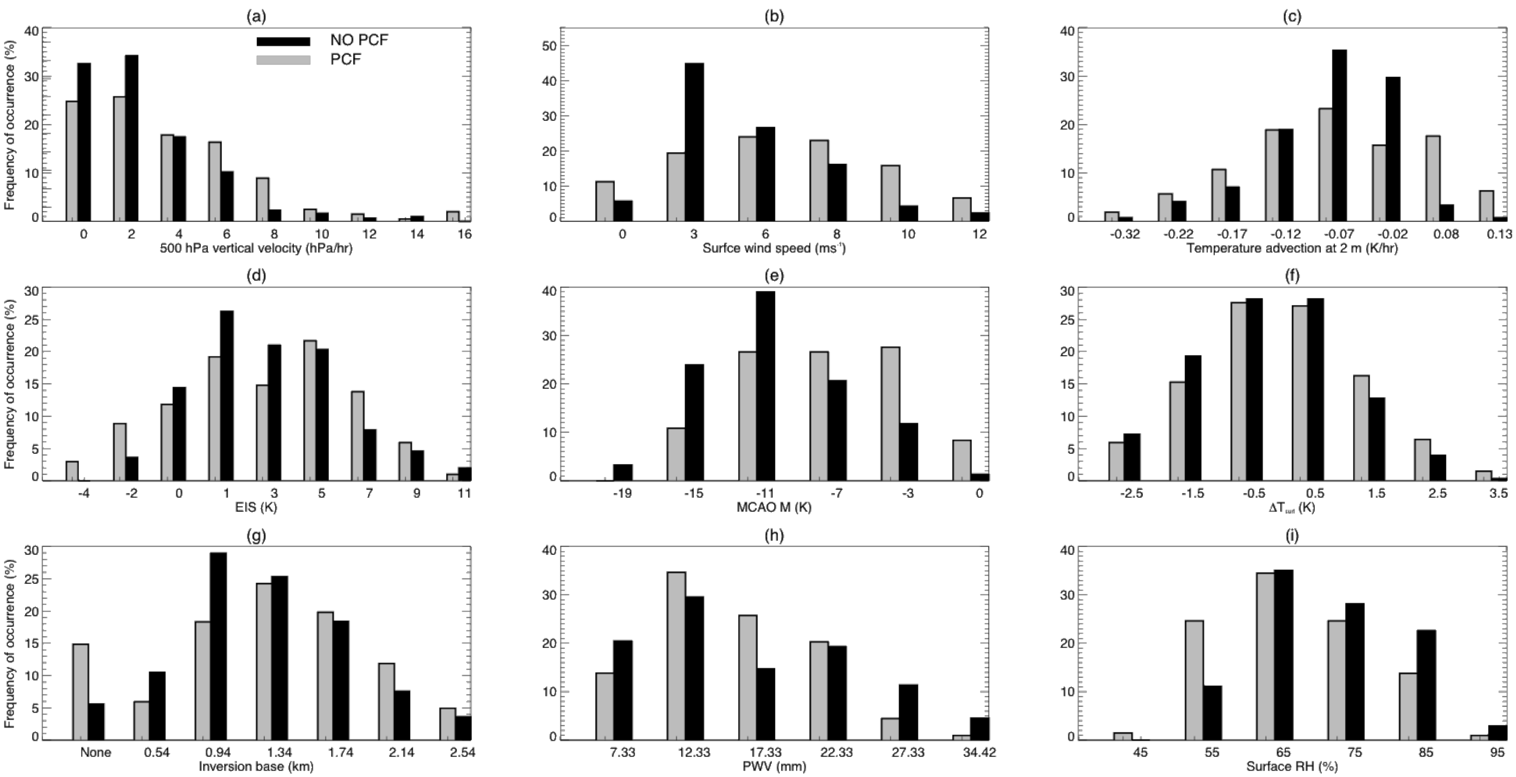


Solid = non-PCF

Dashed=PCF

Clouds are higher in PCF conditions, because PBL is deeper

Environment: PCF vs. non-PCF



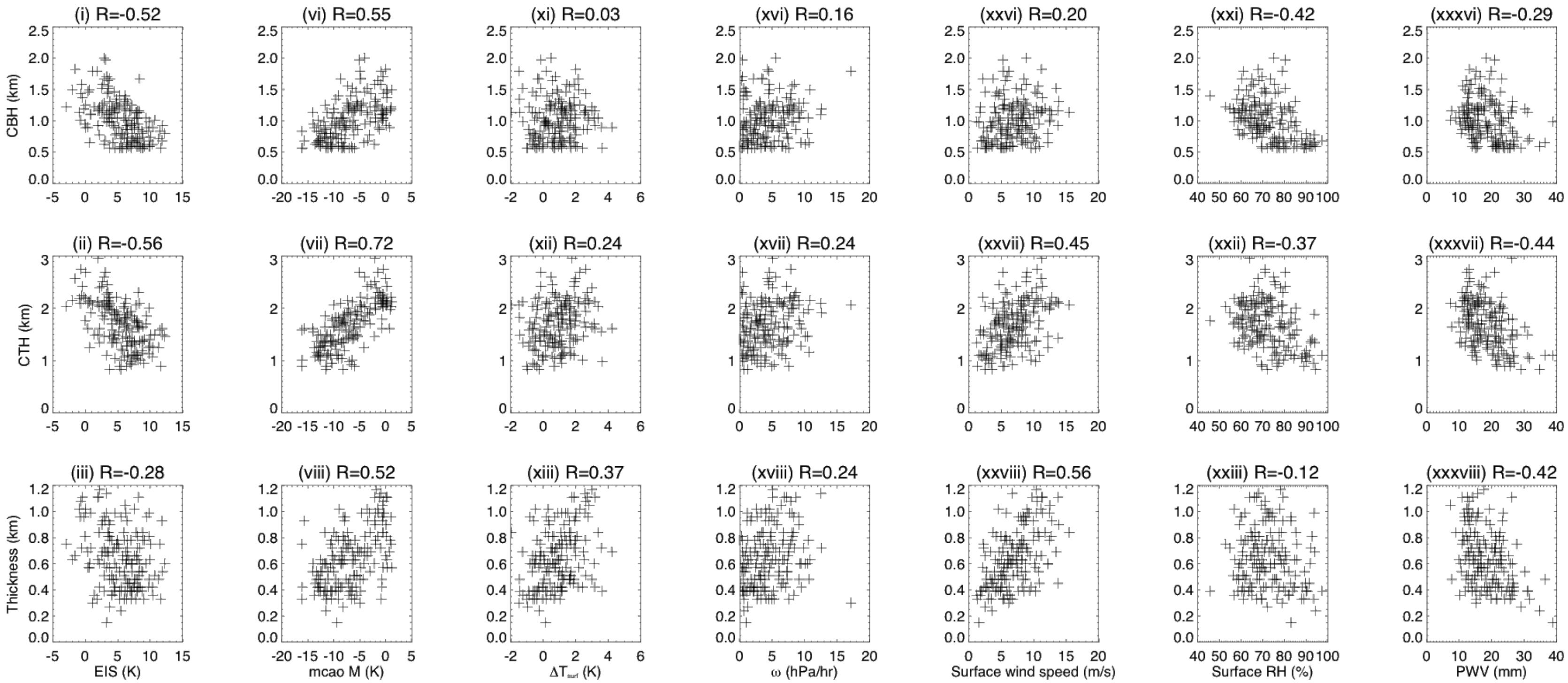
- PCF dynamically more active: stronger subsidence (a), stronger surface winds (b)
- EIS and M indicate lower stability in PCF (d,e) while surface temperature contrast/forcing slightly stronger for PCF (f)
- Inversion occurs less often in PCF than non-PCF, but when it does, it is higher (g)
- RH & PW indicate drier conditions in PCF (h,i)

What matters most for cloud boundaries in PCF?

CBH

CTH

Vertical extent



CBH: stability (EIS/M) and moisture (RH/PW)

CTH: stability (M) and surface wind

Cloud vertical extent: stability (M) and wind

Stability surface forcing Dynamics Moisture

What did we learn? How can ACE-ENA help?

- Cloud Boundaries driven by interplay between lower troposphere stability (EIS) and surface fluxes (wind, temperature contrast) => this makes M a good metric
- In non-PCF, weaker winds mean weaker sensible heat flux, so M is smaller than for PCF, but M still main driver of cloud boundaries

- These results only involve cloud boundaries (base and top heights), but liquid/ice content unknown, and radiative impact too => ACE-ENA could help
- February 15 2018: cold front passage at ENA followed by PCF for long enough period of time
- Multiple cases of non-PCF periods prior, with northerly winds and anticyclone necessary for comparison.